Bussey Bridge Disaster, aka Forest Hills Bridge, 1887

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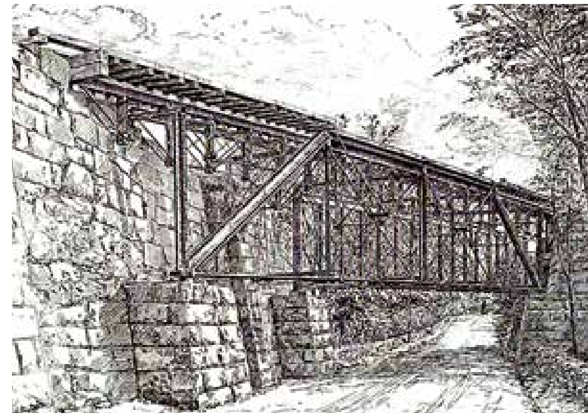
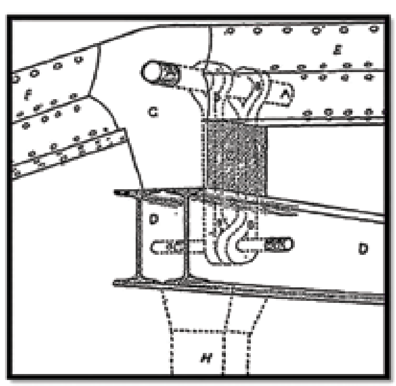


Bussey Bridge – Truss A in foreground, Whipple in background.

The Boston & Providence Railroad built the Dedham Branch running southwesterly from Boston towards Dedham, Massachusetts. The 120-foot-span Bussey Bridge was located six-miles out of Boston and crossed South Street in Roslindale at a 45-degree skew angle. Originally a wooden bridge, sized for two tracks but only carrying one, it sat on masonry abutments. It was called the "Tin Bridge" as the wood was covered with tin to minimize the threat of fire. As the wood decayed, one of the wooden trusses was replaced with an iron Whipple Truss bridge, and the deck structure was supported by this hybrid bridge. In 1876, the railroad decided to replace the remaining wooden truss with another iron truss. *Engineering News* described the bridge as follows,

"In 1869, one of the trusses was replaced by a wrought iron…by C. H. Parker, the other wooden truss being retained. Finally, in July 1876, this iron truss was shifted to the opposite side of the bridge from which it had originally been, and another wrought-iron truss of entirely different design and dimensions was built…and the two trusses united together by laterals into one bridge. The first built truss, B, was a double intersection Pratt truss [Whipple]. It measures 104 feet center to center of end pins, and had 16 panels of 6 feet 6 inches each and a depth of 12 feet 6 inches, center to center of pins. The end posts and top chord were built of plates and angles... The intermediate posts were 8-inch I-beams. The diagonal rods had one pin-end connected to the top chord and one screw-end connected by a casting to the bottom chord, and the bottom chord consisted of four 6-inch bars, varying in thickness from $\frac{3}{4}$ to $\frac{7}{8}$ inches. Truss A measured 104 feet center to center of end pins, had four panels of 26 feet each, and a depth of about 16 feet. It had pin connections, diagonal end posts, and built closed columns, with cast-iron connections. The bridge was about 18 or 20 feet wide."



Cast Iron Junction Box, hangers and cross beams, trussing rods under beams, and diagonals dropping down from the top pin not shown.

The designer of the bridge was Edmund H. Hewins. He offered to build it for $4,500 as "a thoroughly first-class structure in every respect, including a special brand of iron for all tension members, superior exactness of manufacture, and in strength to be fully up to that specified." In his later testimony to a Coroner's inquest, he testified,

"My name is Edmund H. Hewins; …was the builder of a portion of this bridge. The contract required me to build a truss to be placed upon the westerly side of the bridge, or on the side nearest Boston, replacing an iron truss which had been there for some years, and which was to be placed on the easterly side of the bridge; and I was to furnish a floor system. That was done in the spring or early summer of 1876. I was in business for myself; my first experience in building iron bridges was with the Detroit Bridge & Iron Works of Detroit, Mich., I think in 1863; I am not sure whether this wasn't the last bridge that I built; since then I have acted occasionally as consulting engineer; I was at the Lawrence Scientific School at Cambridge one year; then went to Detroit, where I was employed by the Detroit Bridge & Iron Works to design their bridges; designed one across the Mississippi river where C. B. & Q. Railroad crosses it, at that time the longest draw-bridge in the world; built several other bridges on that road, and the Illinois Central road, and in several of the Western States; afterward went South for one winter, returned North, and was employed by the Moseley Iron Works, and the New England Iron Company as engineer; then built some bridges on my own account at least until this bridge was built… can't tell how many I built before the Bussey bridge; think it was somewhere in the neighborhood of half a dozen."

It was possible to place the cross beams on top of the Whipple Truss since its top chord was built of a flat plate and channels. The top chord of the Pratt Truss was built up of phoenix sections connected with cast iron junction blocks, so it was not possible to place the cross beams on top of them. Hewins designed a special cast iron junction box that enabled him to have crossbeam hangers suspended from a pin in the box.

Since these hangers were inside the cast-iron box, they were not readily accessible for inspection. Hewins used the Phoenix Iron Works sections for his tension members and top chord sections. The rest of the ironwork was done by the Trenton Iron & Steel Company to his design. Apparently, the railroad company relied entirely on Hewins to design and build the bridge with no outside inspection. Hewins testified he test-loaded the bridge with two of the heaviest locomotives on the line and the bridge only deflected $\frac{5}{16}$ – $\frac{8}{16}$ inch. Hewins estimated his new truss carried from $\frac{3}{4}$ to $\frac{4}{5}$ of the total load because the track was closest to that truss, and no member, tension or compression, was subjected to a stress greater than 10,000 psi.

Over the years of its use, some passengers expressed concern about the safety of the bridge. The Railroad, however, later testified, "We have a competent engineer in the employ of the company who examines the tracks and bridges several times a year. Bussey Bridge, along with the rest, has been examined recently, and no adverse report has reached the officials. For aught the company knew, that bridge was perfectly sound. That it gave way is certain, and this was no doubt the cause of the accident."

That was the situation until the morning of March 14, 1887, when a northerly bound train with nine passenger cars crossed the bridge at a speed of about 15 miles per hour, and the bridge collapsed, killing 26 people. The engineer, Walter White, who had run trains on the line for over 30 years later testified,

“As we approached Tin Bridge, there was no appearance whatever of danger. The bridge lay as solid and safe as ever, the span across showing no weakness, and gradually the train approached. The engine and tender had passed when I looked backward at the cars behind me...However, as I cast a glance at the train behind, I saw the first car swing inward and topple over as though about to fall, and while I still looked, amazed and bewildered, the second and the third cars tipped over in similar positions, and all finally jumped the track. The engine kept to the rails, however, and I turned for a moment to slack my engine. When I looked back, and the time consumed was a very brief minute, of the nine cars but three remained in sight, and the cloud of dust which rose prophetic over the bridge told to a certainty the fate of the remainder.”


Aftermath.

Newspapers ran very descriptive stories of the disaster, and the *Boston Globe* sent Henry Prichard, a local engineer, to the site to report on the disaster. Professor George Swain of MIT visited the site shortly after and wrote,

“In looking at one of these hangers, where one floor beam was hung at the end joint of the upper chord, I found that the hangers were defective and had been largely rusted off. These hangers were made with a weld, and the weld seemed to be in some places imperfect, and it seemed to me extremely probable that at this joint where the hangers were broken, the original rupture might have occurred…

There seems to be no doubt that the quality of the material was imperfect in some places… The angle of skew of the bridge was very large. The skew bridge is more difficult to design correctly than a straight one, but it is perfectly easy to make a skew bridge perfectly strong… The hanging of the floor beams to the upper chord of a deck bridge is a fault in design and very easily avoided.”

George Vose testified, “I think that bridge, in its general plan and in its details, was a standing invitation to be knocked to pieces, and I think the immediate cause of the trouble was those broken links…The thing was waiting to tumble down. That is *my* opinion of that bridge.”

The Railroad Commissioners of Massachusetts, consisting of three men, had a 420-page report with illustrations. They interviewed many people, including engineers Henry Manley, George Swain, George Vose, Edward Philbrick, and Thomas Doane. They concluded,

“As it happened, the accident was not caused by defects of the system, but the management is none-the-less censurable for its long-continued neglect to remove this undoubted element of danger. The contract for the rebuilding of the bridge in 1876 was made without proper examination as to the standing of the contractor. Those who acted for the corporation in making the contract had not sufficient knowledge of iron bridge building to enable them to pass intelligently upon the design and specifications. The design and specifications for the bridge were not such as should have been accepted. The bridge was constructed practically without superintendence on the part of the corporation, and the corporation neglected to preserve a copy of the specifications, drawings, and strain sheets.

Notwithstanding the repeated warnings of the board, the spaces between the ties on this bridge were far too great for safety; and, notwithstanding the recommendation of the board in 1881, no suitable guardrails or guard timbers were placed upon the bridge.

The disaster and the facts which have been disclosed impose a grave responsibility on the Board of Directors. It is their duty, by the most searching inquiry, to ascertain forthwith whether any other work has been done in a like negligent and incompetent manner, whether in other matters reasonable and well-proved precautions against accidents have been ignored or neglected and whether false economy has been practiced and safety sacrificed…

As bridges embody many possibilities of danger, it is proper that special means should be taken to secure careful, competent, and faithful construction, and a thorough and scientific examination of them by the railroads at regular intervals, followed by a thorough State inspection…

The board recommends the passage of an act requiring every railroad, at least once in two years, to have a thorough examination of all bridges on its lines made by a competent and experienced Civil Engineer, who shall report in writing to the corporation and to the Board of Railroad Commissioners the results of his examination, his conclusions, and recommendations.”

Engineering News published many articles on the failure and was very critical of the Railroad and Hewins. An article on March 19th entitled, *The Second Ashtabula Disaster* concluded,

“As for the bridge itself, we would not forget, nor lead others to forget, that the Boston & Providence Railroad has been and is, in the main, a truly enlightened, liberal, and well-officered and managed corporation...But we need not point out to engineers that a more grotesque and fantastic parody on the accepted canons of good practice than this strange structure could hardly be found unless in its now illustrious predecessor, the one-iron-truss-one-wooden-truss combination…

Nothing in the catastrophe tends to show that the trusses themselves were too weak, and there has been no time for making the necessary computations. But the badness of their design in many details, we may almost say in every detail, will be at once evident…The hangers…were so boxed in with cast-iron that a real inspection must have been difficult or impossible after erection, but the badness of the fragments now in our office, at least, must have been obtrusively evident during erection.”

The *Boston Globe* summarized the bridge as, “Bad in contract, bad in make, bad in testing, and very bad in general.”

Like in other disasters, lawsuits were settled by the Boston & Providence Railroad. The 23 deaths and 100 injuries resulted in claims of $450,000 and almost bankrupted the company. Old Colony took it over in 1888. Like the Dixon Bridge Collapse and the Ashtabula Bridge failure, this disaster was partly due to the poor decisions made by the engineer. The reader is encouraged to read the *Special Report by the Massachusetts Board of Railroad Commissioners to the Legislature in Relation to the Disaster on Monday, March 12, 1887*, for more on the disaster, available online in Public Document No. 14, 1888, contained in the 17th Annual Report of the Railroad Commissioners January 1886.▪

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